10-24-00

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PATENT TRADEMARK OFFICE

JC575 U.S. PTO 10/23/00

Practitioner's Docket No. 16219-1

PATENT

Preliminary Classification:
Proposed Class:
Subclass:

JC913 U.S. PTO 09/696523 10/23/00

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of

Inventor(s): Ji (nmi) SU; Joycelyn S. HARRISON

For (title): MEMBRANE POSITION CONTROL

CERTIFICATION UNDER 37 C.F.R. SECTIONS 1.8(a) AND 1.10*
*(When using Express Mail, the Express Mail label number is **mandatory**;*
Express Mail certification is optional.)

OCT 27 2000

I hereby certify that, on the date shown below, this correspondence is being:

MAILING

[ ] deposited with the United States Postal Service in an envelope addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.
37 C.F.R. Section 1.8(a)

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37 C.F.R. Section 1.10*

TRANSMISSION

[ ] transmitted by facsimile to the Patent and Trademark Office (703) ____-____

Date: Oct. 23, 2000

Robin W. Edwards
Signature

ROBIN W. EDWARDS
(*type or print name of person certifying*)

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The PTO did not receive the following listed item(s) Post Card

1. **Type of Application**

This transmittal is for an original (nonprovisional) application.

2. **Papers Enclosed**

A. Required for filing date under 37 C.F.R. 1.53(b) (Regular) or 37 C.F.R. 1.153 (Design) Application

6 Page(s) of Specification
2 Page(s) of Claims
4 Sheet(s) of Drawing(s)--Informal

B. Other Papers Enclosed

2 Page(s) of declaration and power of attorney–inventors unavailable for signature
1 Page(s) of Return Postal Card

3. **Declaration or Oath**

Enclosed
Unexecuted by:
* inventors.

4. **Inventorship Statement**

The inventorship for all the claims in this application is the same.

5. **Language**

English

6. **Assignment**

An assignment of the invention to Administrator, National Aeronautics and Space will follow.

7. **Fee Calculation (37 C.F.R. Section 1.16)**

Regular Application

CLAIMS AS FILED

Claims	Number Filed	Basic Fee Allowance	Number Extra		Rate	Basic Fee 37 CFR 1.16(a) $710.00
Total Claims (37 CFR 1.16(c))	14	- 20 =	0	x	$18.00	$0.00
Independent Claims (37 CFR 1.16(b))	1	- 3 =	0	x	$80.00	$0.00
Multiple Dependent Claim(s), if any (37 CFR 1.16(d))				+	$270.00	$0.00
			Filing Fee Calculation			$710.00

8. **Fee Payment Being Made at This Time**

Enclosed

Filing Fee	$710.00
Total Fees Enclosed	$710.00

9. **Method of Payment of Fees**

Charge Account No. 14-0116 in the amount of $710.00.
A duplicate of this transmittal is attached.

10. **Authorization to Charge Additional Fees**

The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No. 14-0116.

37 C.F.R. Section 1.16(a), (f) or (g) (filing fees)
37 C.F.R. Section 1.16(b), (c) or (d) (presentation of extra claims)
37 C.F.R. Section 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)
37 C.F.R. Section 1.17(a)(1)-(5) (extension fees pursuant to SECTION 1.136(a))
37 C.F.R. Section 1.17 (application processing fees)
37 C.F.R. Section 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. Section 1.311(b))

11. Instructions as to Overpayment

Credit Account No. 14-0116.

12. Relate Back

Amend the specification by inserting, before the first line, the following sentence:
N/A

13. Maintenance of Copendency of Prior Application

A. Conditional Petition for Extension of Time in Prior Application
A conditional petition for extension of time is being filed in the pending **prior** application.
. N/A

14. Further Inventorship Statement Where Benefit of Prior Application(s) Claimed

Date: Oct. 23, 2000

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Practitioner's Docket No. LAR 16219-1 *PATENT*

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: SU, Ji (nmi); HARRISON, Joycelyn S.

Application No.: Group No.:
Filed: Examiner:
For: MEMBRANE POSITION CONTROL

Assistant Commissioner for Patents
Washington, D.C. 20231

EXPRESS MAIL CERTIFICATE

"Express Mail" label number EK16158112
Date of Deposit 10/23/2000

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NEW UTILITY PATENT APPLICATION

is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. section 1.10, on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

ROBIN W. EDWARDS

Robin W. Edwards

Signature of person mailing paper or fee

Return Postal Card
Org & 1 transmittal form
Specification, Claims, Abstract - 9 pgs
Declaration (NASA Form 1538)
4 sheets INFORMAL drawings

MEMBRANE POSITION CONTROL

Claim of Benefit of Provisional Application

Pursuant to 35 U.S.C. §119, the benefit of priority from provisional application 60/161,113, with a filing date of October 22, 1999, is claimed for this non-provisional application.

Cross Reference to Related Cases

This application is related to co-pending, commonly owned patent application Serial No. _____, filed October 23, 2000, entitled "Polymer-Polymer Bilayer Actuator", and co-pending, commonly owned patent application Serial No. _____, filed October 23, 2000, entitled "Non-Uniform Thickness Electroactive Device."

Origin of the Invention

The invention described herein was made by an employee of the United States Government and a National Research Council Research Associate and may be used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

Background of the Invention

Field of the Invention

The present invention is generally related to the control of membrane structures by electroactive bending actuators.

Description of the Related Art

Membrane inflatable and deployable space structures are widely employed by the government and commercially as reflectors, antennas, solar arrays, satellites, solar sails, etc. Although these membrane inflatable and deployable structures are widely used, many challenges exist which limit their performance for high precision applications. Factors affecting precision include surface smoothness, deviation from desired surface profile, surface deformations due to thermal fluctuations, and accurate membrane positioning. Actuation devices are used for many applications, including the shaping, tuning, positioning, controlling and deforming of membrane structures. To operate most effectively in the aforementioned applications, actuation devices require sufficient force and strain, and often need to produce complex motions.

Conventional piezoelectric ceramic, polymer, and composite actuators (including piezoelectric, electrostrictive, and electrostatic) lack the combination of sufficient strain and force to most effectively perform the aforementioned functions. Previous concepts for shaping and tuning membrane structures have primarily involved the use of piezoelectric ceramic materials. These ceramic piezoelectrics have the major problems of large mass, high density, low strain and high brittleness. Generally, piezoceramics also need additional mechanical devices to achieve a shaping, tuning, positioning, controlling or deforming function. In contrast to electroceramics, electroactive polymers are emerging as new actuation materials due to their enhanced strain capabilities.

Summary of the Invention

Accordingly, an object of the present invention is to provide an electroactive position control device.

Another object is to provide an electroactive position control device wherein the electroactive components have small mass, low density, high strain and low brittleness.

Another object is to provide an electroactively-controlled membrane.

Another object is to provide an electroactively-controlled membrane inflatable and deployable structure.

Another object is to provide an electroactive position control device using electrostrictive bending actuators.

Additional objects and advantages of the present invention are apparent from the drawings and specification that follow.

In accordance with the present invention, a membrane structure includes an electroactive device fixed to a supporting base. A connection means operatively connects the electroactive device to the membrane for controlling membrane position.

Brief Description of the Drawings

A more complete appreciation of the invention and the many of the attendant advantages thereof will be readily attained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 illustrates a membrane structure having integrated electroactive positioning actuators.

FIGs. 2A through 2D illustrate four positioning states of a membrane.

FIG. 3A illustrates a connection means operatively connecting the electroactive device to the membrane for controlling membrane position.

FIG. 3B illustrates a side view of FIG. 3A.

FIG. 3C illustrates a partial cross-sectional view of FIG. 3B.

FIG. 4 is an alternate embodiment of the connection means.

Detailed Description of the Invention

Referring now to the drawings, and more particularly to FIG. 1, a membrane structure according to the present invention is shown and referenced generally by the numeral 100. Membrane 110 is to be controlled. Membrane 110 can be of any shape. Supporting frame 140 supports the

membrane 110. Supporting base 120 is connected to a strut assembly 130. Strut assembly 130 is connected to additional structure within the overall structural system. The supporting base 120/strut assembly 130 structure is indicative of usual support and overall system interface for membrane structures; however, the present invention is not limited to such specific configuration. Actuators 150, 160 and 170 are affixed to supporting base 120 adjacent to the supporting base 120 periphery. Actuators 150, 160 and 170 bend upon electrical activation. Electrostrictive actuators are preferred due to their high mechanical modulus and strain combination. An especially preferred actuator is the polymer-polymer actuator described and claimed in "Polymer-Polymer Bilayer Actuator", Serial No. _____, filed October 23, 2000, hereby incorporated by reference. The actuators 150, 160 and 170 can also have non-uniform layer thickness, as that described in and claimed in "Non-Uniform Thickness Electroactive Device", Serial No. _____, filed October 23,2000, hereby incorporated by reference.

Referring to FIGs. 2A through 2D, connection means 180 operatively connects the membrane 110 and actuators 150 and 160. FIGs. 2A through 2D illustrate four positioning states of a membrane 110. The actuators are in their inactivated state in FIG. 2A. FIG. 2B illustrates tilting of the membrane 110 resulting from bending of the actuator 150. FIG. 2C illustrates tilting of the membrane 110 resulting from bending of the actuator 160. FIG. 2D illustrates a state in which the membrane 110 is raised as a result of bending by both of the actuators 150 and 160. The bending contour of each of the actuators 150 and 160 will depend upon their materials, their drive voltages, whether they have non-uniform layer thicknesses, as well as other variables, such as electroding methodology. For ease of illustration, displacements of only two actuators, 150 and 160, are shown. It should be understood that none, one, two or three actuators may be electrically activated at any time. The states shown are merely illustrative and positioning capability of each actuator is tailorable via the actuator design, placement and number. Furthermore, any number of actuators may be used, although the three-actuator placement is preferred to obtain the most stability and degrees of freedom.

FIGs. 3A through 3B illustrate one embodiment of connection means 180. FIG. 3B is a side view of FIG. 3A. FIG. 3C illustrates a partial cross section of FIG. 3B. Bending actuator 160 is affixed to supporting base 120. Either chemical or mechanical means may be used. Chemical means are preferred, such as the chemical adhesive epoxy. The amount the actuator 160 overlaps the supporting base 120 depends on the affixation means employed. The size, including length, width and thickness, of the actuator also vary depending on the desired range of bending displacement that is desired and are selected accordingly. The actuator 160 is movably connected to membrane 110 via a guiding track 210 and guiding wheel assembly, wherein the guiding wheel assembly includes the guiding wheels 200 and axle 220. The guiding track 210 is affixed to the membrane 110 by chemical or mechanical means. Mechanical means are shown. The guiding wheels 200 maintain movement of the axle 220 along the guiding track 210, and are positioned along the axle 220 a sufficient distance from the guiding track 210 to allow free movement of the axle 220 along the guiding track 210. The guiding track 210 and guiding wheel assembly may be plastic, metal, or other suitable material. Plastic is preferred due its lower weight. Guiding axle 220 is affixed to the bending actuator 160 using chemical, such as epoxy, or mechanical, such as fastener, means. The connecting means 180 allows for rotation of the bending actuator 160 in a positive direction, i.e., in the direction towards the membrane, and back to its non-activated position. In operation, the bending actuator 160 responds to the output of one or more sensors located on membrane 110 via an integrated feedback control system. As the bending actuator 160 bends due to electrical activation from a drive voltage (not shown), the guiding wheels 200 translate along the guiding tracks 210, and displacement of the membrane 110 is effected. Another embodiment of the connection means 180 is illustrated in FIG. 4. In this embodiment, guiding track 310 guides upper and lower guiding wheels 300. Any connection means that effectively translates motion of the actuator 160 to the membrane 110 is acceptable.

Obviously, numerous additional modifications and variations of the present invention are possible in light of above teachings. It is therefore to be

understood that within the scope of the appended claims, the invention may be practiced otherwise than is specifically described herein.

What is claimed is:

Claims:

1. An electroactively controlled membrane structure, comprising:

a membrane whose position is to be controlled;

a supporting base;

at least one electroactive bending actuator affixed to the supporting base; and

connection means corresponding to each of the at least one electroactive bending actuators for operatively connecting the membrane to each of the at least one electroactive bending actuators;

wherein displacement of the at least one electroactive bending actuator effects displacement of the membrane.

2. The structure of claim 1, wherein the at least one electroactive bending actuator is a polymer-polymer bilayer actuator.

3. The structure of claim 2, wherein the polymer-polymer bilayer actuator comprises at least one layer of an electrostrictive material.

4. The structure of claim 1, wherein the at least one electroactive bending actuator comprises at least one layer of an electrostrictive material.

5. The structure of claim 1, wherein the at least one electroactive bending actuator is fixed to the supporting base by means selected from the group consisting of mechanical and chemical.

6. The structure of claim 1, wherein the at least one electroactive bending actuator is fixed to the supporting base by a chemical adhesive.

7. The structure of claim 1, comprising three electroactive bending actuators affixed to the supporting base, wherein the connection means operatively connects the three electroactive bending actuators to the membrane, thereby providing three points of control to the membrane.

8. The structure of claim 1, wherein each connection means comprises:

a guiding wheel assembly and a track, wherein displacement of the actuator effects translation of the wheel assembly along the track, thereby imparting movement to the membrane.

9. The structure of claim 1, wherein each connection means comprises:

a guiding track affixed to the membrane;

a guiding wheel assembly, the guiding wheel assembly further comprising an axle, affixed to the electroactive bending actuator, and four guiding wheels which maintain movement of the axle along the guiding track;

whereby bending of the actuator effects displacement of the membrane.

10. The structure of claim 9, wherein the guiding track is affixed to the membrane by means selected from the group consisting of chemical and mechanical.

11. The structure of claim 9, wherein the guiding wheels are position a sufficient distance form the guiding track to allow free movement of the axle along the guiding track.

12. The structure of claim 9, wherein the guiding wheel assembly is made of a material selected from the group consisting of plastic and metal.

13. The structure of claim 9, wherein the guiding track is made of a material selected from the group consisting of plastic and metal.

14. The structure of claim 1, wherein the bending actuator comprises at least one layer of an electrostrictive material having a nonuniform thickness.

MEMBRANE POSITION CONTROL

Abstract

A membrane structure includes at least one electroactive bending actuator fixed to a supporting base. Each electroactive bending actuator is operatively connected to the membrane for controlling membrane position. Any displacement of each electroactive bending actuator effects displacement of the membrane. More specifically, the operative connection is provided by a guiding wheel assembly and a track, wherein displacement of the bending actuator effects translation of the wheel assembly along the track, thereby imparting movement to the membrane.

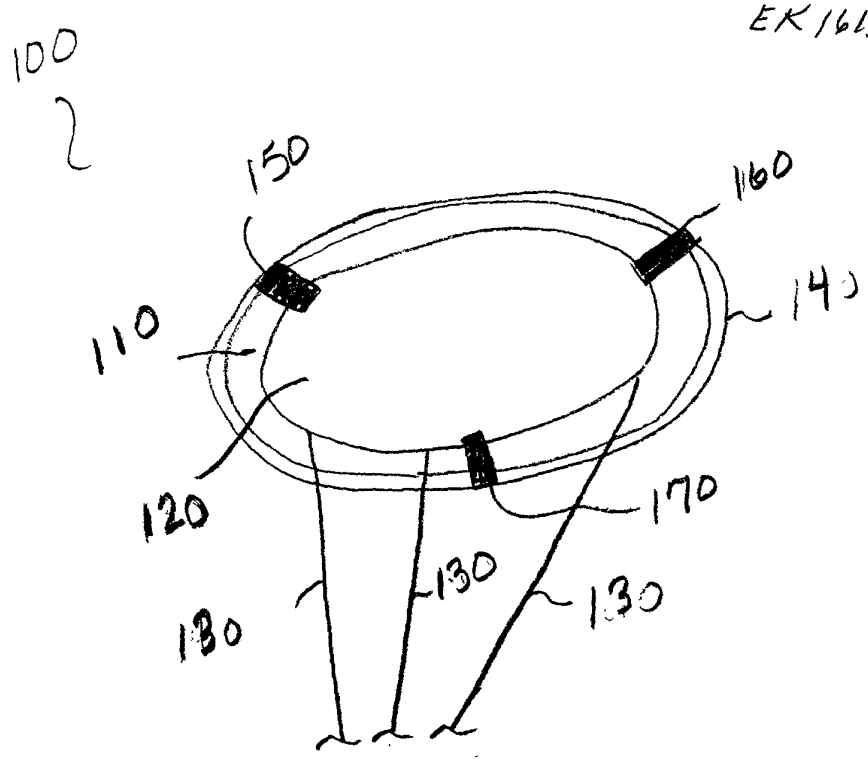

FIG. 1

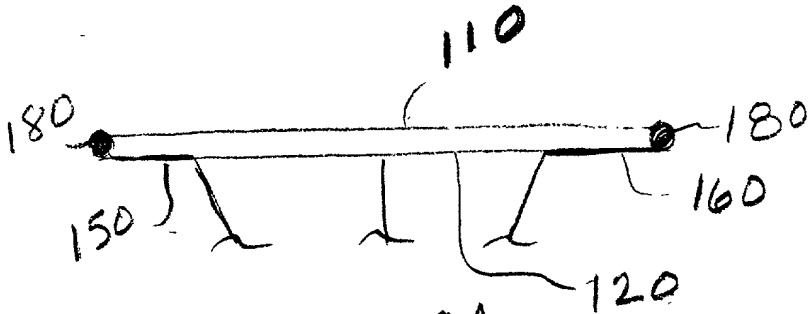

FIG. 2A

FIG. 2B

FIG. 2C

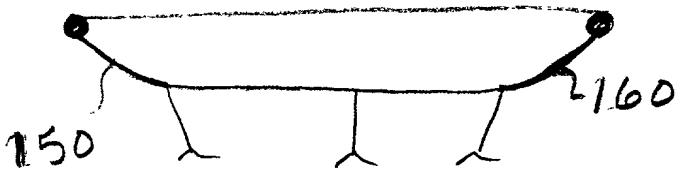

FIG. 2D

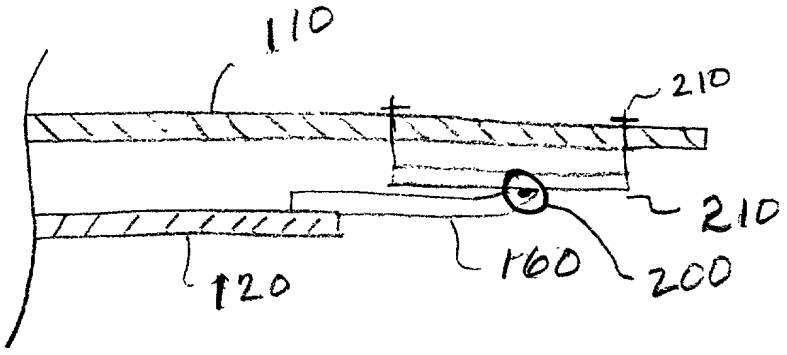

FIG. 3A

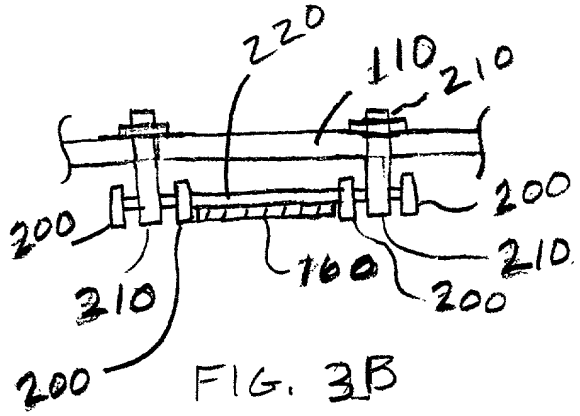

FIG. 3B

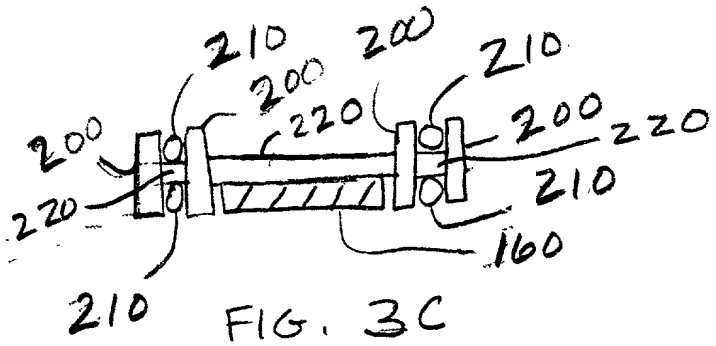

FIG. 3C

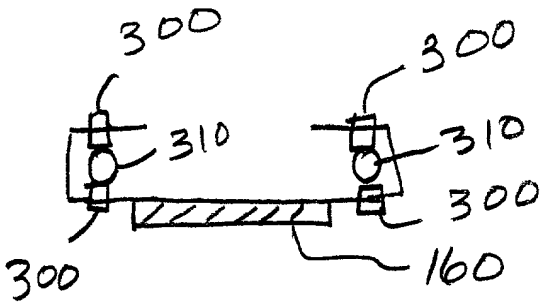

FIG. 4

National Aeronautics and
Space Administration

NASA Case No.: 16219-1

DECLARATION, POWER OF ATTORNEY AND PETITION - ORIGINAL APPLICATION

As a below named inventor, I hereby declare that: my residence, post office address and citizenship, are stated below next to my name, I believe I am the original, first and sole inventor (If only one name Is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled MEMBRANE POSITION CONTROL, the specification of which ✓ is attached hereto, __ was filed on (Date) _____ as Application Serial No. _____ and was amended on (Date)_____.

I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the Patent and Trademark Office all information which is known to me to be material to patentability as defined in 37 CFR §1.56.

I hereby claim the benefit under 35 U.S.C. §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of 35 U.S.C. §112, I acknowledge the duty to disclose to the Patent and Trademark Office all information known to me to be material to patentability as defined in 37 CFR §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:____ _ (Serial No.), _____ (Filing Date) ,the status of which is

_ patented, __ pending, _ abandoned.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(e) of any United States Provisional applications listed below:

PROVISIONAL APPLICATION NUMBER	FILING DATE
60 / **161,113**	**October 22, 1999**
_____ / _____	_____,

the status of which is

_ patented, ✓ pending, _ abandoned.

POWER OF ATTORNEY: I hereby appoint the following attorney(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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Further, as a named inventor I certify that the Governmment of the United States of America, as represented by the Administrator of the National Aeronautics and Space Administration, has x an assignment in, or _ license to the invention set forth in this application and has the irrevocable right to practice this application and to receive the patent.

Wherefore, I pray that Letters Patent be granted to me for this invention or discovery described and claimed in the foregoing specification and claims, and I hereby subscribe my name to the foregoing specification, claims, power of attorney and this petition.

I hereby declare that all statements made herein of my own knowledge are true and that - statements made on information and belief are believed to be true; and further that these, statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. §1001; and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

FULL NAME OF INVENTOR	LAST SU	FIRST Ji	MIDDLE OR INITIAL (nmi)
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POST OFFICE	STREET NO. AND NAME 803C Donaldson Street	CITY AND STATE OR (COUNTRY) Highland Park, New Jersey	ZIP CODE 08904
SIGNATURE			DATE

FULL NAME OF INVENTOR	LAST HARRISON	FIRST Joycelyn	MIDDLE OR INITIAL S.
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SIGNATURE			DATE

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POST OFFICE	STREET NO. AND NAME	CITY AND STATE OR (COUNTRY)	ZIP CODE
SIGNATURE			DATE